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POTENTIAL MIGRATION OF CONTAMINATED GROUNDWATER TO LAKES LADORA AND LOWER DERBY

December 1990

PREPARED BY

U.S. ARMY CORPS OF ENGINEERS
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THE PURPOSE OF THIS REPORT IS TO EVALUATE THE POTENTIAL FOR GROUND WATER CONTAMINANTS IN THE SOUTH PLANTS TO MIGRATE TOWARDS AND INTO LAKES LADORA AND LOWER DERBY.

THE REPORT INCLUDES INFORMATION ON THE FOLLOWING:

1. GROUND WATER FLOW
2. GROUND WATER AND SURFACE WATER RELATIONSHIPS
3. NATURE AND EXTENT OF CONTAMINATION IN LAKE WATER, SEDIMENT, AND BIOTA
4. ENVIRONMENTAL BEHAVIOR OF CONTAMINANTS DETECTED.

CONCLUSIONS INCLUDE THE FOLLOWING:

1. WHETHER GROUND WATER CONTAMINATION HAS OR WILL MIGRATE INTO THE LAKES CANNOT BE DETERMINED CONCLUSIVELY BECAUSE OF DATA GAPS.
2. THE PRIMARY PATHWAYS FOR CONTAMINANTS MAY BE SURFACE WATER SEDIMENT TRANSPORT PROCESSES.
3. CONTAMINATION LEVELS HAVE NOT INCREASED SIGNIFICANTLY OVER THE PAST

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1.0 EXECUTIVE SUMMARY

1.1 PURPOSE AND SCOPE

The purpose of this report is to evaluate the potential for groundwater contaminants in the South Plants area to migrate towards and into Ladora and Lower Derby Lakes. All contaminants detected in monitor wells in the South Plants area are evaluated regardless of the plume they may be associated with. The study has four primary objectives: (a) to determine if any groundwater contaminants from the South Plants area will reach Lake Ladora and Lower Derby Lake prior to implementation of the final remedy, (b) to determine what contaminants, if any, are currently in the two lakes, (c) to determine what threat, if any, the contaminants may pose to humans and the biota of the lakes, and (d) to determine if groundwater is the primary pathway of contaminants detected in the lakes.

The study integrates historical information, the results of previous investigations, and current reports on surface water, sediment, groundwater, biota, and human exposure. This information is used to present an overall contamination assessment of both lakes. Collectively, this information has been evaluated to accomplish the objectives of the study.

1.2 CONCLUSIONS

The conclusions of this study are based on the interpretation of the available information. The following conclusions were made concerning the objectives of this study.

a. Lower Derby Lake is a groundwater recharge source, and the average lake elevation of 5,247 ft is typically above the surrounding water table. For this reason Lower Derby Lake may not be affected by contaminated groundwater.

b. Lake Ladora is a groundwater discharge area, and the average lake elevation of 5,208 ft is typically below the surrounding water table. For this reason, Lake Ladora can be affected by groundwater

influx to the lake from the east and discharge from the lake to the groundwater westward. Raising Lake Ladora to its highest possible level may decrease the hydraulic gradient between the lake and the up gradient groundwater surface and thus, slow the inflow of groundwater into the lake.

c. Contaminants are present in the surface water and sediment of both Lake Ladora and Lower Derby Lake. Mercury is present in Lake Ladora, and chlordane is present in Lower Derby Lake at concentrations above EPA's water quality criteria for chronic levels in fresh water. The concentrations of other contaminants in the water of both lakes is below EPA water quality standards.

d. Contaminants have migrated adjacent to Lake Ladora and Lower Derby Lake in the alluvial groundwater. The CMP plume maps show contaminants have migrated to the edge of the both lakes (CMP Annual Ground Water Report For 1989). Groundwater from the area is recharging Lake Ladora. The probable minute volume of groundwater entering the lake and the low concentrations of contaminants that may be present in the groundwater will be diluted upon entering the lakes. The large volume of water in the lake is several orders of magnitude greater than the volume of groundwater flowing into the lake and very accurate monitoring will be necessary to determine long term environmental impacts.

e. The data suggest that surface water sediment transport processes may be a primary pathway for the contaminants detected in the lakes. Both Lake Ladora and Lower Derby Lake were contaminated as part of the process water system from 1942 to 1964. The lakes were connected to the manufacturing facility and to each other by a ditch system. In 1964 both lakes were drained to excavate contaminated sediment. An analysis of the lakes' sediment after excavation indicated that contaminant concentrations were reduced but contaminants were still present. There is no indication that contaminated sediment was removed from the ditch system. This ditch system is a likely source of transported contaminated sediment .

f. The annual biota report (1989) indicates that several contaminants were detected in biota samples. The source of the contaminants found in the biota can not be determined. The present concentrations detected in biota samples are below the EPA criteria

for aquatic life. Further contamination eventually may pose a risk to nonhuman biotic life through bioaccumulation, although the present situation of the lakes appears to be stable

g. The contamination detected in the lakes will not pose a risk to human life. The current policy on swimming and the catch and release policy for fishing in both lakes will help prevent any possible risk to humans.

h. The contamination levels in the lakes apparently have not increased significantly over the past several years. The data indicate that the lakes and biota contamination levels have decreased when compared to the high concentrations detected between 1942 and 1964. The present situation of the lakes appears to be stable and should remain so until the implementation of the final remedy; therefore, there is no significant benefit in terms of cost for accelerated cleanup of the lakes.

2.0 SITE DESCRIPTION

Prior to the establishment of Rocky Mountain Arsenal (RMA) in 1942, the area known as the Southern Study Area (SSA) was primarily used for agricultural and rural residential usage. Before the construction of RMA both Lower Derby and Lake Ladora existed as irrigation reservoirs. The lakes were constructed using dikes and were lined with clay to prevent seepage. Since the establishment of RMA, various waste may have been accidently discharged into several sites in the area. These sites include both Lake Ladora and Lower Derby Lake, ponds, and the ditch system. Lake Ladora is located in the southern portion of Section 2 (Figure 1) and occupies an area of about 66 acres (Remedial Investigation Report, Volume VI, Southern Study Area, Ebasco Services 1989). Lower Derby Lake lies in the southern portion of section 1 (Figure 1) and is east of Lake Ladora, north of 6 th Avenue, and west of "E" Street. Lower Derby Lake has a total area of about 73 acres (Final Surface Water Assessment Report for 1988, R.L. Stollar & Associates 1990).

2.1 SOUTH PLANTS LAKE HISTORY

Water from Lake Ladora and Lower Derby Lake was used as a part of the South Plants cooling system. The South Plants cooling water system was a looped system composed of a distribution and return water system. The Army designed and constructed the cooling water system during the initial construction of RMA and it became operational in 1942. The initial system provided cooling water for the South Plants manufacturing complex which produced military chemicals for the Army. The water from Lake Ladora was pumped via underground pipes to the buildings where it was used for cooling purposes. Once used, the process water was returned to Upper Derby Lake by a gravity feed system which utilized a network of pipes and open ditches for recirculation back into the lakes for storage and cooling prior to reuse. The lakes are all interconnected by ditches or inlets allowing water to move from Upper Derby Lake to Lower Derby Lake and then over to Lake Ladora completing the cooling system cycle.

The first reported incident of contamination in the lakes was in the early 1950's when an accidental discharge into the process water system caused a massive fish kill. Subsequent testing of the water, sediment, and algae of Lake Ladora and Lake Mary indicated the presence of aldrin, dieldrin, gardona (insecticide), bidrin (organophosphate insecticide) and heavy metals. Samples from Lower Derby lake were reported to contain no toxic compounds. Shell (1952), documented the first occurrence of pesticides in Lower Derby Lake. Dieldrin was detected in the surface water at a concentration of 1 part per million (ppm), and aldrin was detected in the lake foam at a concentration of 68 ppm. Subsequent testing 2 years later did not detect any pesticides. Contaminants could have migrated to the lakes through the groundwater, pipelines, ditches and other sources. The recirculated cooling water may have become contaminated as a result of defective or faulty equipment. Contaminants from other locations may have migrated to Lower Derby Lake and then to Lake Ladora via the ditches and/or inlet channel. Aldrin and dieldrin may have been introduced to the lakes by surface runoff from the salvage yard where

contaminated material was cleaned. Throughout this period, large quantities of dead waterfowl (approximately 1,200) were found in and around the lakes. As a result of these deaths, more sampling was conducted by the U.S. Fish and Wildlife Service(USFWS). Concentrations of dieldrin as high as 261 ppm were found in the tissues of waterfowl taken from near the lakes. In April 1959 the USFWS began a study to investigate the waterfowl mortalities.

The USFWS study reported a relationship between the waterfowl mortalities and the area of exposed contaminated lake bottom sediments. The contaminants found in the lake sediments were aldrin and dieldrin primarily, which were adversely impacting the environment. In 1959 the lakes were unable to support aquatic life (Remedial Investigation Report, Volume VI, Southern Study Area, Ebasco Services 1989).

Sediment sampling of Upper and Lower Derby Lakes in late 1963 and early 1964 indicated the presence of aldrin (up to 183 ppm), dieldrin (up to 12.7 ppm), isodrin(up to 8.3 ppm), and endrin (up to 10 ppm). None of the above compounds were detected in Lake Ladora. A closed loop cooling tower system was constructed in 1964. This system effectively removed the lakes from the cooling water system. In the summer of 1964, Lower Derby was drained and up to 12 in. of contaminated lake bottom sediments were removed (Contamination Assessment Report, Upper and Lower Derby Lakes, Ebasco Services Incorporated 1987).

In late 1964 and early 1965 Lake Ladora was drained and up to 12 in. of contaminated lake bottom sediments were removed. The lake was then refilled and stocked with fish. The excavated sediments were reported to have contained 25 to 50 ppm of aldrin and dieldrin. (Contamination Assessment Report, Lake Ladora and Lake Mary, Ebasco Services Incorporated, July 1987).

Subsequent sediment sampling indicated locations in the lakes where pesticides were still concentrated. This prompted the removal of an additional 6 to 24 inches of contaminated sediments. Shell's subsequent analysis of the lake sediments from Lake Ladora still indicated the presence of contaminants. The highest concentration of contaminants was in the inlet channel leading from Lower Derby Lake. The inlet was excavated and a new channel built. In 1982 and 1983

Shell and the US Army Engineers Waterways Experiment Station (USAEWES) conducted a follow-up study of pesticide contamination of the lakes. The results of the study indicated a need for additional removal of contaminated lake bottom sediments from both Derby Lakes to reduce contamination levels in the lakes. In 1984 the USFWS completed its sediment dating study by concluding that since the early 1970's the contaminant situation in both Lake Ladora and Lower Derby Lake has been stable. The areas containing the highest concentrations of organochlorine pesticides and metals were located in the ditch systems, lake inlets, deeper areas of the lakes, and areas of channelized flow (Remedial Investigation Report, Volume VI, Southern Study Area, Ebasco Services 1989).

2.2 GROUNDWATER FLOW

The water table occurs in alluvium in the northwestern and southeastern portions of the study area, and in the weathered Denver Formation immediately southwest of the South Tank Farm (Final Alternatives Assessment, Other Contamination Sources, Interim Response Action, South Tank Farm Plume, Shell 1990). A groundwater mound (high) under the south plants area has been indicated from the water levels since 1957 and possibly earlier. The groundwater flows radially away from this groundwater mound. This radial flow from the groundwater mound is one of the primary influences on the contaminant migration from the South Tanks Farm Area (STFA).

The lithology beneath the south plants area is predominantly claystones and volcanoclastic materials of the Denver Formation. The Denver Formation has a higher elevation in the STFA than in the surrounding region. This bedrock high exerts a profound influence on the migration of contaminants in the area. The claystones and volcanoclastic materials have a lower hydraulic conductivity than the surrounding alluvial materials. The differences in the hydraulic conductivities of the materials and the higher Denver Formation. elevations may be sufficient to produce the groundwater mounding in the South Plants Area. The recharge of the groundwater mound beneath the South Plants has been enhanced as a result of leaking

water pipes and sewer lines, ponding of water in the low areas, and activities in the South plants area. In 1980 a major leak in the sewer system was identified and corrected. Since then the groundwater mound has declined 1 to 2 ft. (Remedial Investigation Report, Volume VI, Southern Study Area, Ebasco Services 1989). A later Shell report indicates the groundwater mound has declined approximately 5 ft. since 1988 (Hydrologic and Water Quality Report, Shell1990).

The weathered Denver Formation and the alluvial aquifers are connected such that groundwater flowing from the South Tank Farm area will initially move through the weathered Denver Formation, and then through the alluvial aquifer eventually inflowing through a portion of the lakes bottom.

The hydraulic gradient in the South plants area varies significantly from .01 to .0001 ft/ft between the tank farm and the lakes. The water table gradient from the South Tank Farm area to Lake Ladora averages approximately 0.009 ft/ft. Hydraulic conductivity estimates for the weathered Denver Formation were calculated from single-well injection (slug) tests conducted during the fall of 1989 in the South Plant area. The averaged hydraulic conductivity ranges from 9.1×10^{-4} cm/sec to 3.7×10^{-4} cm/sec based on several tests conducted in wells 02505, 02598, and 01580 (Final Alternatives Assessment, Other Contamination Sources, Interim Response Action, South Tank Farm Plume, Shell 1990).

Between 1983-84 and 1990, contaminants advanced at an approximate rate of 33 ft/year in the weathered Denver Formation. This observed approximate migration rate correlates well with the interstitial groundwater flow velocity of 28 ft/year calculated using the estimated hydraulic conductivity of 9.1×10^{-4} cm/sec groundwater gradient of 0.009 ft/ft and an assumed effective porosity of 0.3 (Final Alternatives Assessment, Other Contamination Sources, Interim Response Action, South Tank Farm Plume, Shell 1990).

The unconfined alluvium aquifer has a hydraulic conductivity that ranges from 2.6×10^{3} to 1.7×10^{2}. ft/day (Annual Ground Water Report for 1989, 1990). The average hydraulic gradient varies from approximately .0001 to .01 ft/ft., and the assumed effective porosity varies from .1 to .3 (Proposed Final Water Remedial Investigation Report, June 1989). The average linear velocity along the south-

southwest pathway from the water table mound to Lake Ladora in alluvium is stated to range from 0.017 ft/day to 2.1 ft/day (Proposed Final Water Remedial Investigation Report, June 1989). The corresponding groundwater travel time from the center of the water table mound to Lake Ladora would range from 2.8 to 249 years. A CMP report indicates that the leading edge of several contaminant plumes are adjacent to Lake Ladora and Lower Derby Lake (CMP Annual Ground Water Report For 1989). However, the actual contamination migration rate in the alluvial aquifer near the lakes is not known. The migration rate is controlled locally by fluctuations of the lake water levels and the surrounding groundwater table.

2.3 GROUNDWATER AND SURFACE WATER RELATIONSHIPS

To determine whether groundwater contaminants may reach Lower Derby and Ladora Lakes, it is important to assess the relationship between the surface and groundwater systems, and specifically determine the potential for discharge of contaminated groundwater to the lakes.

Initial studies which tried to quantify gain-loss relationships between surface and groundwater systems were conducted by RCI (1982, 1983, 1984, and 1987). These studies emphasized gain-loss calculations for the South Plants Lakes. In a one month water balance calculation for March 1987 areas of groundwater discharge was identified at Lake Ladora (Final Alternatives Assessment, Other Contamination Sources, Interim Response Action, South Tank Farm Plume, Shell 1990). Areas of groundwater recharge from surface water have been noted in the western portion of Lake Ladora and in the northwest portion of Lower Derby Lake. Areas of groundwater discharge into the lakes have also been noted in the eastern portion of Lake Ladora (Final Surface Water Assessment Report 1988). Analyses conducted for the Comprehensive Monitoring Program (CMP) report indicate that groundwater discharge into the southeast portion of Lower Derby Lake, but the Water Remedial Investigation report (WRI) indicated that Lower Derby Lake is not recharged by groundwater (Final Surface Water Assessment Report 1988). The proposed final water remedial investigation report in 1989 and all other information

used in this study indicate that Lower Derby Lake is not recharged by groundwater. It is generally believed and accepted that Lower Derby Lake is not recharged by groundwater because the lake elevation of 5,247 ft. is typically above the water table.

Under the Task 4 and 44 programs conducted by Hunter/ESE (1988a and 1988b) additional stream flow and groundwater level data were gathered to delineate areas of gain or loss to the surface water system. The WRI report (Ebasco Services, Inc. 1989) interpreted data available up to 1987 and indicated locations and estimated values of recharge and discharge between surface water bodies and the unconfined groundwater system. Water balance calculations were completed for the lakes area. A CMP surface water monitoring program indicated a net discharge from groundwater into Lake Ladora and a net loss to the ground water system by Lower Derby Lake when the lakes are filled with water (Ebasco Services, Inc. 1989).

The volume of groundwater potentially entering Lake Ladora cannot be determined from available information. Any volume of groundwater entering the lake will be several orders of magnitude smaller than the volume of water in the lake. The average volume of Lake Ladora is 346.8 acre-ft. This large difference between influx and lake water volumes should decrease the concentrations of contaminants in the inflowing groundwater.

The configuration of the groundwater table for the (STFA) indicates that the magnitude of any groundwater discharge into Lake Ladora from the groundwater system should decrease if the lake water level maintained at an elevation of 5,220 ft. A lake level of 5,220 ft. should create a hydraulic gradient between the lake surface water and the alluvial groundwater system that will prevent or minimize the migration of contaminants moving in the alluvial groundwater toward the lakes (Regional Groundwater Study RMA 1982).

3.0 CONTAMINANTS

This study addresses all contaminants detected above Certified Reporting Limits (CRLs), in the groundwater near the lakes, surface water, and lake sediments. Consideration is given to all contaminants which may impact the lakes. The contaminants detected in monitoring wells upgradient from the lakes, along with Lake Ladora and Lower Derby Lake water, sediment, and biota are listed Appendices A through F. The primary contaminant of all four medium; (groundwater, surface water, lake sediment, and biota indigenous) to the lakes is the Organochlorine Pesticides (OCPs). Other contaminant groups represented are as follows:

a. Volatile Halogenated Organic Compounds (VHOs)
b. Volatile Aromatic Organic Compounds (VAOs)
c. Dibromochloropropane (DBCP)
d. Metals
e. Volatile Hydrocarbons (VHCs)
f. Organophosphorus Compounds(OPHs)
g. GB-Agent Related Organophosphorus Compound (OPHGBs)
h. Organosulfur Compounds Herbicide Related (OSCHs)
i. Organosulfur Compounds Mustard Related (OSCMs)

3.1 MONITOR WELL CONTAMINATION

Several contaminant categories are represented in the groundwater adjacent to the lakes. The category found most often in the groundwater is the OCP. OCP's are represented by aldrin, dieldrin, endrin, isodrin, DDE, DDT, and chlordane. VHO's were also detected in the groundwater. VHO's are represented by chloroform, 1 1 dichloroethane, carbon tetrachloride, 112 trichloroethane, T-1,2-dichloroethylene, chlorobenzene. VAOs and DBCP were also present in the groundwater. VAO's are represented by benzene, toulene and xylene. Metals were also detected in the groundwater near the lakes. Arsenic, mercury, and cyanide were detected in several of the wells. Other contaminant groups detected above the CRL's are as follows:

a. (VHC's), Bicycloheptadiene, Dicyclopentadiene
b. (OPH's), Atrazine, Malathion, Parathion, Supona
c. (OPHGB's), Dimp, Dmmp
d. (OSCH's), Chlorophenyimethyl sulfone
e. (OSCM's), Dithiane

Figure 2 and 3 shows the geographical relationship between the monitoring wells evaluated and the lakes. A list of the groundwater contamination data is given in Appendix A. Appendix A also indicates the aquifer in which the monitor well is screened.

3.2 LAKE WATER CONTAMINATION

The surface water data for the lakes indicate the presence of three contaminant groups in Lake Ladora and Lower Derby Lake. These contaminants are chlordane (OCP's), arsenic, mercury, lead (metals), and chloroform(VHO's). Lake Ladora had arsenic, mercury, lead, and chloroform present in its water. Lower Derby Lake had chlordane and arsenic present in its surface water. Arsenic was the only contaminant found in the surface water samples from both lakes. All the contaminants were detected at a depth of 2 ft. or greater from the surface of the lakes.

Previous surface water sampling of the lakes from 1983 to 1987 for OCP's, VHO's, arsenic, and metals indicated none of the contaminants were detected (Final Water Remedial Investigation Report 1989). Whether the samples were taken at the surface of the lake or at a specific depth is unknown.

The primary contaminant pathway into the surface water of the lakes, be it groundwater migration and/or surface runoff, cannot be ascertained due to limited and conflicting data.

A list of the surface water contamination data for 1989 is given in Appendix B.

3.3 LAKE SEDIMENT CONTAMINATION

The data used in this investigation indicate the presence of five contaminant groups whose concentrations exceeded the CRL's. These are OCP's (aldrin, dieldrin, endrin, and DDE), OPHP's (atrazine, and vapona), Metals (lead, mercury, arsenic), DBCP, and the Semivolatile Halogenated Organics (SHOs), represented by hexachlorocyclopentadiene(Cl_6 CP).

Lake Ladora sediments from sample areas 1 and 2 (Figure 4) showed some contaminants were above the CRL's at the lake bottom surface. The contaminants found in area 1 at this depth were aldrin, atrazine, dieldrin,and vapona. Area 2 sampling at the same depth indicated the presence of the same contaminants plus DBCP. That the contaminants were found at such shallow depths indicate that some sediment accumulation of the contaminants is occurring. Lower Derby Lake sediments did not exhibit the contaminant concentrations in the shallow sediments that were shown by Lake Ladora. The sampling locations for Lower Derby Lake is shown in Figure 5.

Whether the accumulation was from the groundwater or more likely surface runoff from other sources cannot be ascertained. The other sample locations in both lakes indicates a higher concentration of contaminants at greater depth. From the previous sampling, a general trend can be seen where the overall contamination of the lakes sediment seems to be decreasing. A list of the lake sediment contamination data is given in Appendix C.

3.4 BIOTA CONTAMINATION

In biota samples taken from both lakes, several contaminants were detected. Dieldrin was detected in all 15 samples of bluegill, largemouth bass, and American coots (duck) taken from Lake Ladora.

In Lower Derby Lake dieldrin was detected in four of the five bluegill samples taken. All five of the largemouth bass specimens contained dieldrin. Only two of the five bullhead samples contained dieldrin. Dieldrin was detected in both killdeer (bird) specimens.

In Lake Ladora endrin was detected in one of five largemouth bass samples. DDE was also detected in Lake Ladora in three of the five largemouth samples.

In Lower Derby Lake DDE was detected in only the largemouth bass and killdeer specimens.

Mercury was detected in biological samples from all RMA lakes sampled in 1989. Overall, the highest concentration of mercury detected in aquatic samples from RMA (0.57 µg/g) was from a largemouth bass specimen taken from Lake Ladora. The specific concentrations of mercury in biota from Lake Ladora are listed in Appendix D. Four of five bluegill samples contained mercury. All five of the largemouth specimens had concentrations of mercury. The metal was also detected in three of the four American coots sampled.

Mercury was detected in all three fish species collected from Lower Derby Lake. All the bluegill samples contained mercury. All the largemouth bass samples had mercury present. Five of five bullhead samples taken from Lower Derby Lake had concentrations of mercury. Mercury was also detected in one of two killdeer sampled.

Several factors affect the ability of flora and fauna to accumulate contaminants. These include simple ingestion, soil type, contaminant concentration, organic content, the particular biological species, season, and contaminant solubility.

The biota contamination investigation of the lakes indicates that some contaminants have reached Lake Ladora and Lower Derby Lake and have influenced the ecosystem of the lakes. The particular migration pathway(s), be it groundwater flow through the alluvial aquifer and/or accumulation of contaminated sediments from surface water transport, cannot be ascertained.
The biota sampling results are shown in Appendix D.

4.0 ENVIRONMENTAL BEHAVIOR OF CONTAMINANTS

The chemical and physical behavior of the contaminants detected in the monitor wells, lake surface water, sediments, and biota are presented below. The ultimate fate of contaminants is influenced by the physical and chemical properties of the specific contaminants and the characteristics of their environment. The

predominant contaminants detected are organochlorine pesticides (OCP's), dieldrin, aldrin, and endrin.

Organochlorine pesticides degrade slowly in soil environments (with half-lives ranging from 1 to 14 years) and have low solubilities and mobilities in aqueous environments (Edwards 1973, Holtbold 1974, Khan 1980, and USEPA 1987). The distribution of OCPs is a function of the amount of clays or organic matter present in soil. These contaminants tend to adhere strongly to naturally occurring organic matter. The chemical nature of OCP's suggests that OCP's may be transported by air or surface water runoff while adhering to fine grained particles. The relatively low mobility rates and wide dispersion of the OCP's suggest that surface water runoff was the main contributor for migration (Final Remedial Investigation Report Southern Study Area 1989). Bioaccumulation of OCP's has been detected in biota common to the Southern Study Area (Final Biota Annual Report 1989).

Volatile halogenated organics were found to be present in the groundwater at levels above the CRL but not in the surface water or lake sediments. The high volatility of the VHO's may be one reason that the contaminant was missing from the surface water and sediment of the lakes. This same high volatility may allow the contaminants to migrate vertically as well as laterally through the alluvial soils to the lakes. The accumulation potential of VHO's in the lake biota was low (Final Remedial Investigation Report Southern Study Area 1989).

Volatile aromatic organics (VAO's) were detected in the groundwater adjacent to the lakes and in one sample from Lower Derby Lake sediments at levels above the CRL. The VAO contaminants have moderate solubilities and volatilize quite readily. The high volatility of the VAO's, as with the VHO's explains the lack of VAO's in the surface water and infrequent occurrence and low concentrations in the lake sediments. The VAO's tend to mobilize moderately and have a low affinity for adhering to organic matter and clay minerals. Bioaccumulation potential for VAO's in the lakes was low (Final Remedial Investigation Report Southern Study Area 1989).

The groundwater analysis indicates the presence of organosulphur compounds herbicide and mustard related OSC's. The

groundwater contains the only occurrence of OSC's close to Lower Derby Lake. OSC's have variable (moderate to high) solubilities and moderate to high volatility. OSC's have low to moderate affinity for adhering to organic matter and clay particles. Most of the contaminants from this group are moderately mobile in aqueous environment and are susceptible to surface runoff transportation. Herbicide related OSC's have been noted to undergo microbial degradation in the field, though the data regarding this is unavailable (Final Remedial Investigation Report Southern Study Area 1989). Bioaccumulation of OSC's in the lakes is unlikely.

Dibromochloropropane (DBCP) was also detected in the groundwater and lake sediments. DBCP has a moderate affinity for adhering to organic/clay particles and moderate solubility and volatility. DBCP was fairly persistent in subsurface sediments and groundwater, but is degraded slowly by hydrolysis and microbial action. DBCP volatilizes from surface water, although potential transport from surface runoff and sediment transport may be significant. Although DBCP was present in the groundwater and in the lake sediments from Lake Ladora and Lower Derby Lake, it was notably absent in both lakes (Final Remedial Investigation Report Southern Study Area 1989).

Both the groundwater and lake sediments indicated the presence of organophosphorus compounds (OPH's), both pesticide related and GB-agent related. OPH's have variable solubilities ranging from moderate to high, and low to moderate volatilities. Limited volatilization of OPH's can occur from surface water and surficial soils. OPH's do not have a high affinity for organic matter or clay particles, thus resulting in limited transport by surface runoff and sediment transport. In a aqueous environment OPH's hydrolyze slowly. Ingestion of surface water and browse vegetation are the primary pathways for exposure. DIMP was not detected in any of the biota sampled from the lakes' area (Final Remedial Investigation Report Southern Study Area 1989).

Only one contaminant from the Semivolatile Halogenated organic group was found in the study area. The contaminant was hexachlorocyclopentadiene (CL_6CP), and it was detected in only the sediment of Lower Derby Lake. CL_6CP has a low solubility and

moderate to high volatility . The contaminant has a moderate affinity for adhering to organic matter and clay particles. When present in the surface water, it tends to volatilize rapidly, and it's mobility in groundwater is slow. Bioaccumulation of hexachlorocyclopentadiene is not appreciable due to its transformation by photolysis, hydrolysis, and biodegradation (Final Remedial Investigation Report Southern Study Area 1989).

Arsenic was detected in the groundwater and surface water of the lakes. Arsenic has a high affinity for clay minerals/organic matter absorption and may be transported primarily by fluvial or eolian processes. The metal's high affinity for absorption to particles retards lateral and vertical migration . This suggests that the primary migration pathway for arsenic was surface runoff and sediment transport. In aquatic ecosystems, arsenic can accumulate at sufficient concentrations to cause damage to aquatic organisms (Final Remedial Investigation Report Southern Study Area 1989).

Biota sampling of aquatic life of the lakes indicated no concentrations of the metal in fish and aquatic water birds. Arsenic was only detected in sedentary species and plankton (Final Biota Annual Report 1989).

Mercury was present in all three media, groundwater, surface water, and lake sediments of both lakes. The solubility of inorganic mercury in low oxidation states is low, and as a result, mercury in soil is considered relatively immobile. Sorption of mercury was dependent on the organic carbon content and grain size of the soil or sediment. Mercury can volatilize from both aquatic and terrestrial environments. Potential bioaccumulation of mercury in the lakes' region is high (Final Remedial Investigation Report Southern Study Area 1989). Bioaccumulation of mercury has already been detected in biota from the lakes (Final Biota Annual Report 1989).

Surface water transport of sediments was the primary migration pathway for mercury.

The environmental fate of selected contaminants is shown in Appendix E.

5.0 SUMMARY

Based on available current and historical information on the South Plants area, a contamination study of the lakes was conducted. The available material contained conflicting information and data gaps, which made it difficult to draw conclusions. Major areas of conflicting information are (a) the contamination migration rates in the alluvial aquifer, (b) whether Lake Ladora is being recharged by groundwater, and (c) the location of the leading edge of contaminants migrating in the alluvial aquifer. Major data gaps are (a) groundwater contamination information at the lake's edge, (b) hydraulic gradient between groundwater and lake surface water, (c) continuous data collection from the same specific sites and depths, (d) analytical methods used in lake water sampling and testing, and (e) historical data required to determine the contamination trends. The recommendations from this study are based on the interpretation of the available information and the lake's present situation.

Whether groundwater contamination will or has migrated into the lakes cannot be determined conclusively because of conflicting reports and data gaps. Some data suggest that some groundwater contamination may have reached the lakes and will continue to migrate into Lake Ladora and Lower Derby Lake. Data from a RMA groundwater CMP report indicates that the leading edge of several contamination plumes are adjacent to the lakes. Plume maps of dieldrin, volatile aromatic compounds, benzene, chloroform, and volatile organohalogen compounds indicate that these and other contaminant plumes are adjacent to the boundaries of Lake Ladora and or Lower Derby Lake in the unconfined groundwater flow system (CMP Annual Ground Water Report For 1989).

Contaminants have been detected in the surface water, sediment, and biota of both lakes, but the pathway of these contaminants may not be the groundwater. The primary pathway for the contaminants is probably surface water sediment transport processes. Other data show that organochlorine pesticides and other contaminants detected in the groundwater near the lakes were not detected in the surface water of the lakes. This would indicate that groundwater contamination has not and is not reaching the lakes, or

that dilution, settling, biodegradation, and volatilization have reduced the concentrations below detectable limits such that if groundwater contamination has reached the lakes, it has had little effect on the lakes. There was no data to suggest that the lake water or the biota contamination levels have increased over the past several years. The data in fact indicate that the lakes and biota contamination levels have improved when compared to the high contamination levels detected when the lakes were first contaminated between 1942 to 1964. The present situation of the lakes appears to be stable, and the data does not suggest a change in the lakes stability prior to implementation of the final remedy.

The current contamination levels detected in the lakes and the biota do not appear to pose a risk. Further contamination from the South Plants area may pose a risk to nonhuman biotic life if allowed to contribute to the current contamination levels over time and accumulation occurs. The amount of accumulation estimated over the time frame of the IRA should not reach high enough levels to impact the lakes. The current contamination does not pose a risk to human life. Restrictions of no swimming and the catch and release policy for fishing in both lakes will help to ensure that there is no risk to humans.

6.0 REFERENCES

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APPENDIX A - MONITORING WELL CONTAMINATION

This list contains the highest and most recent contaminant concentration detected in the monitor wells evaluated. The aquifer that each well is screened in is specified if known.

Lake Ladora wells:

Well Id	*Test*	*Date*		*Value*		*Aquifer*
02516						
	CLDAN	89311		0.309	µg/l	
	HG	89311	LT	0.500	µg/l	
	DLDRN	89311		0.639	µg/l	
	AS	89311		4.900	µg/l	
02517						
	CCL4	89312		15.00	µg/l	
	HG	89312	LT	0.500	µg/l	
	CHCL3	89312		11.400	µg/l	
	CPMSO2	89312		5.880	µg/l	
	PPDDE	89312		0.114	µg/l	
02518						
	DLDRN	89311		0.101	µg/l	
	HG	89311	LT	0.5 0	µg/l	
02515						
	11DCLE	89311		7.060	µg/l	
	HG	89312	LT	0.500	µg/l	
	CHCL3	89312		58.90	µg/l	
02514						
	11DCLE	89313		5.100	µg/l	
	HG	89313	LT	0.500	µg/l	
	CHCL3	89313		114.0	µg/l	
	DLDRN	89313		0.199	µg/l	
	ENDRN	89313		0.331	µg/l	
02036						Denver
	C6H6	83124		25.0	µg/l	
		89363	LT	1.00	µg/l	
	CHCL3	83124		21.0	µg/l	
		89363	LT	1.00	µg/l	
	CYN	88350		11.20	µg/l	
		89363	LT	5.000	µg/l	
	HG	89363	LT	0.100	µg/l	
02052						Alluvial
	CLDAN	88343		0.664	µg/l	
		88343	LT	37.00	µg/l	
	HG	88166		0.272	µg/l	
		88343	LT	0.100	µg/l	
	SUPONA	88343		1.08	µg/l	
02059						
	ALDRN	89353		0.186	µg/l	
	ATZ	89353		20.70	µg/l	
	HG	89353	LT	0.100	µg/l	
	C6H6	89353		39.60	µg/l	
	CCL4	89353		9.380	µg/l	
	CHCL3	89353		140.0	µg/l	
	CLC6H5	89353		23.00	µg/l	
	CLDAN	89353		0.952	µg/l	
	DBCP	89353		59.00	µg/l	
	DIMP	89353		0.806	µg/l	
	DLDRN	89353		0.125	µg/l	
	ISODR	89353		0.234	µg/l	
	MEC6H5	89353		52.00	µg/l	

Lake Ladora wells:

Well Id	Test	Date		Value		Aquifer
02059						
	PPDDT	89353		0.140	µg/l	
	SUPONA	89353		1.360	µg/l	
	TCLEE	89353		10.80	µg/l	
	TRCLE	89353		4.080	µg/l	
	XYLEN	89353		2.530	µg/l	
02513						
	11DCLE	89313		38.20	µg/l	
	112TCE	89313		1.980	µg/l	
	12DCE	89313		11.30	µg/l	
	CCL4	89313		29.20	µg/l	
	CHCL3	89313		465.0	µg/l	
	HG	90010	LT	0.100	µg/l	
02512	No Data Available					
02511	No Detection Above CRL's					
	HG	89310	LT	0.500	µg/l	
02510	No Data Available					
02509						
	C6H6	90085		377.0	µg/l	
	HG	89311	LT	0.500	µg/l	
	DLDRN	89311		0.511	µg/l	
	ENDRN	89311		1.030	µg/l	
02508	No Data Available					
02034						Denver
	ENDRN	89145		0.154	µg/l	
	PPDDT	89145		0.385	µg/l	
		89363	LT	0.049	µg/l	
	PRTHN	89145		1.630	µg/l	
	TCLEE	89363		1.660	µg/l	
	TRCLE	89363		3.050	µg/l	
	HG	89363	LT	0.100	µg/l	
02035						Denver
	111TCE	87337		0.828	µg/l	
		90003	LT	0.760	µg/l	
	112TCE	87337		1.220	µg/l	
		90003	LT	0.780	µg/l	
	11DCE	87337		9.170	µg/l	
		90003	LT	1.700	µg/l	
02035						Denver
	11DCLE	86007		10.90	µg/l	
		90003		8.150	µg/l	
	HG	86248		0.296	µg/l	
		90003	LT	0.100	µg/l	
	12DCE	87337		1.760	µg/l	
		90003		1.590	µg/l	
	ALDRN	90003		0.151	µg/l	
	C6H6	83124		20.00	µg/l	
		90003	LT	1.500	µg/l	
	CCL4	86248		20.00	µg/l	
		90003		7.460	µg/l	
	CH2CL2	86176		10.00	µg/l	
		90003	LT	7.400	µg/l	
	CHCL3	90003		260.0	µg/l	
		86007		430.0	µg/l	
	CLDAN	90003		0.318	µg/l	
	CYN	88350		6.770	µg/l	
		90003	LT	5.000	µg/l	
	DIMP	90003		0.890	µg/l	

Lake Ladora wells:

Well Id	Test	Date		Value		Aquifer
02035						Denver
	DITH	87337		1.570	µg/l	
		90003	LT	1.340	µg/l	
	ISODR	83124		0.750	µg/l	
		90003	LT	0.051	µg/l	
	PRTHN	88350		1.070	µg/l	
		90003	LT	0.647	µg/l	
	PPDDT	87337		0.762	µg/l	
		90003	LT	0.049	µg/l	
	TCLEE	87337		4.23	µg/l	
		90003		2.51	µg/l	
	TRCLE	87337		11.9	µg/l	
		90003		7.91	µg/l	
02507	HG	89310	LT	0.500	µg/l	
02506						
	11DCLE	90093		63.70	µg/l	
	12DCE	90093		16.80	µg/l	
	C6H6	90093		13.20	µg/l	
	CHCL3	90093		207.0	µg/l	
	TRCLE	90093		3.480	µg/l	
	HG	89310	LT	0.500	µg/l	
02034						Alluvial
	11DCLE	86171		5.650	µg/l	
		89363		2.970	µg/l	
	HG	89363	LT	0.100	µg/l	
	ALDRN	89145		0.683	µg/l	
		89363	LT	0.050	µg/l	
	C6H6	83124		18.00	µg/l	
		89363		7.690	µg/l	
	CHCL3	83124		30.00	µg/l	
		89312		10.00	µg/l	
	CPMSO2	87127		3.890	µg/l	
		89363		7.460	µg/l	
	DIMP	89145		1.290	µg/l	
02034						Alluvial
	DLDRN	83124		0.320	µg/l	
		89363	LT	0.050	µg/l	
	DMMP	88349		1.970	µg/l	
		89363		0.188	µg/l	
02034						Alluvial
	ISODR	89145		0.361	µg/l	
		89363	LT	0.051	µg/l	
	PPDDE	88349		0.0822	µg/l	
		89363	LT	0.054	µg/l	
	SUPONA	89145		1.970	µg/l	
	TRCLE	86171		5.020	µg/l	
		89363		3.050	µg/l	
02060	No Detection Levels above CRL's					Unknown
	HG	89360	LT	0.100	µg/l	
02020						Alluvial
	11DCE	89360		1.980	µg/l	
		87335		4.000	µg/l	
	12DCE	89009	LT	0.760	µg/l	
		87335		1.740	µg/l	
	CHCL3	86260		40.00	µg/l	
		89360	LT	0.500	µg/l	
	CYN	89009		15.70	µg/l	
		89360		5.000	µg/l	

Lake Ladora wells:

Well Id	*Test*	*Date*		*Value*		*Aquifer*
02020						Alluvial
	DLDRN	85260		0.650	µg/l	
		89360		0.386	µg/l	
	PPDDT	86175		0.239	µg/l	
		89360	LT	0.049	µg/l	
	TRCLE	87335		9.840	µg/l	
		89360	LT	0.560	µg/l	
02021						Denver
	11DCLE	89360		10.50	µg/l	
	12DCE	89360		5.840	µg/l	
	CHCL3	89360		49.40	µg/l	
	HG	88053		0.161	µg/l	
		89360	LT	0.100	µg/l	
	TRCLE	88347		1.030	µg/l	
		89360		0.780	µg/l	
02023						Alluvial
	ALDRN	85077		0.230	µg/l	
		89352		0.189	µg/l	
	ATZ	89352		6.870	µg/l	
	CLDAN	88348		1.140	µg/l	
		89352		1.040	µg/l	
	C6H6	83138		52.00	µg/l	
		89352		1.050	µg/l	
	CHCL3	83138		67.00	µg/l	
		89352	LT	0.500	µg/l	
	DIMP	88348		0.459	µg/l	
		89352	LT	0.392	µg/l	
	DLDRN	89312		0.156	µg/l	
	ENDRN	89312		0.389	µg/l	
		89352	LT	0.050	µg/l	
	MLTHN	89352		0.741	µg/l	
	PPDDE	88348		0.064	µg/l	
		89352	LT	0.054	µg/l	
02023						Alluvial
	SUPONA	88348		0.988	µg/l	
		89352		0.787	µg/l	
	TCLEE	89352		1.210	µg/l	
	TRCLE	83138		1.000	µg/l	
		89352	LT	0.560	µg/l	
	HG	89352	LT	0.100	µg/l	
02024						Denver
	CHCL3	83138		122.0	µg/l	
		88347		2.360	µg/l	
	C6H6	83138		2.000	µg/l	
		89156	LT	1.050	µg/l	
	HG	89156	LT	0.100	µg/l	
	DIMP	89156		0.449	µg/l	
		88347		0.507	µg/l	
	MLTHN	88347		3.770	µg/l	
		89156		0.373	µg/l	
	TCLEE	83138		5.000	µg/l	
		88347		4.630	µg/l	
02025						Denver
	ALDRN	88347		0.0578	µg/l	
		89352		1.200	µg/l	
	C6H6	86023		1.940	µg/l	
		89352	LT	1.050	µg/l	
	CHCL3	83138		3.000	µg/l	
		89352		1.200	µg/l	
	CPMSO2	87131		3.160	µg/l	
		89352	LT	7.460	µg/l	

Lake Ladora wells:

Well Id	*Test*	*Date*		*Value*		*Aquifer*
02025						Denver
	DLDRN	86023	GT	1.040	µg/l	
		89352	LT	0.050	µg/l	
	ENDRN	86023		0.464	µg/l	
		89352	LT	0.050	µg/l	
	HG	88029		0.147	µg/l	
		89352	LT	0.100	µg/l	
02025						Denver
	PPDDT	88029		0.190	µg/l	
		89352	LT	0.049	µg/l	
02038						Denver
	CHCL3	83119		33.00	µg/l	
		88349		7.380	µg/l	
	C6H6	83119		16.00	µg/l	
		89157	LT	1.050	µg/l	
	CLDAN	88349		0.535	µg/l	
		89157		0.664	µg/l	
	DBCP	86006		0.143	µg/l	
		89157	LT	0.195	µg/l	
	DIMP	88349		0.0466	µg/l	
		89157	LT	0.392	µg/l	
	DLDRN	89157		0.866	µg/l	
	HG	89157	LT	0.100	µg/l	
02039						Denver
	CHCL3	87335		26.10	µg/l	
		89353		0.500	µg/l	
	CYN	88350		7.180	µg/l	
		89353	LT	5.000	µg/l	
	HG	89353	LT	0.100	µg/l	
02001						Alluvial
	CLDAN	89312		0.976	µg/l	
	DLDRN	89312		1.720	µg/l	
02002						Alluvial
	C6H6	89353		2.190	µg/l	
	CCL4	89353		7.260	µg/l	
02037						Alluvial
	ISODR	88349		0.237	µg/l	
		89353		0.164	µg/l	
	PPDE	87118		0.124	µg/l	
		89353	LT	0.054	µg/l	
	HG	89353	LT	0.100	µg/l	
	ALDRN	88349		0.112	µg/l	
		89353		0.104	µg/l	
	CCL4	88349		1.440	µg/l	
		89353	LT	0.990	µg/l	
02037						Alluvial
	CHCL3	83119		72.00	µg/l	
		89353		3.830	µg/l	
	C6H6	83119		34.00	µg/l	
		89353	LT	1.000	µg/l	
	CLDAN	88349		2.100	µg/l	
		89353	LT	0.095	µg/l	
	DIMP	88349		0.563	µg/l	
		89137		0.504	µg/l	
	DLDRN	89353		5.700	µg/l	
	ENDRN	89353		0.108	µg/l	

Lower Derby Lake

Well Id	Test	Date		Value	Aquifer
01586					Denver
	DLDRN	89317		0.0755 µg/l	
	ENDRN	89317		0.0889 µg/l	
	HG	89317	LT	0.1000 µg/l	
	C6H6	90088		15.100 µg/l	
01075					Unknown
	BCHPD	89353		51.400 µg/l	
	CCL4	89353		3.1200 µg/l	
	CHCL3	89353		55.000 µg/l	
	HG	89353	LT	0.1000 µg/l	
	TCLEE	89353		6.5700 µg/l	
	C6H6	89353		15.400 µg/l	
	CLC6H5	89353		11.500 µg/l	
	DBCP	89353		21.000 µg/l	
	DCLB	89353		11.200 µg/l	
	MEC6H5	89353		33.000 µg/l	
01076	No Detections Above CRL'S				
01049					Alluvial
	DLDRN	89314		0.1470 µg/l	
	ENDRN	89314		0.1710 µg/l	
	ISODR	83124		0.5800 µg/l	
01050					Denver
	ALDRN	89317		0.1050 µg/l	
	DLDRN	89317		0.3680 µg/l	
	ENDRN	89317		0.6070 µg/l	
	TCLEE	88022		198.00 µg/l	
		89317	LT	2.9000 µg/l	
01050					Denver
	CHCL3	88022		0.9590 µg/l	
		89317	LT	1.7000 µg/l	
	CPMSO	88022		23.600 µg/l	
		89317	LT	1.9800 µg/l	
	CPMSO2	88022		7.3800 µg/l	
		89317	LT	2.2400 µg/l	
01027					Alluvial
	C6H6	83136		2.0000 µg/l	
		88050	LT	1.7000 µg/l	
	CHCL3	83136		2.0000 µg/l	
		88050	LT	0.5000 µg/l	
01028					Denver
	DLDRN	89314		0.1230 µg/l	
	ENDRN	89314		0.1960 µg/l	
01027					Alluvial
01029					Denver
	CLC6H5	90009		2.0800 µg/l	
01048					Denver
	CYN	89010		12.300 µg/l	
		89360	LT	5.0000 µg/l	
	CHCL3	83124		2.0000 µg/l	
		89360	LT	0.5000 µg/l	
01073					
	111TCE	90002		1.4500 µg/l	
	CLC6H5	90002		3.1600 µg/l	
	DBCP	90002		6.2000 µg/l	
	MEC6H5	90002		9.3600 µg/l	
01070					Alluvial
	CHCL3	88166		15.600 µg/l	
		89003		1.1300 µg/l	
	CYN	89003		22.000 µg/l	
	DLDRN	89003		0.1870 µg/l	
	ENDRN	89003		0.0607 µg/l	

APPENDIX B - LAKE WATER CONTAMINATION

The following list contains the contaminant concentrations detected in Lake Ladora and Lower Derby Lake. Sampling locations are shown in Figures 1.0 and 2.0. Three asterisks (***) represents concentrations above EPA Water Quality chronic levels.

Lake Ladora :

Site ID	*Depth*	*Parameter*	*Date*	*Value*	*units*
AREA 1	2.3	ARSENIC	89262	2.44	µg/l
AREA 2	4.8	ARSENIC	89262	2.74	µg/l
AREA 3	4.5	MERCURY	89262	0.0179	µg/l***
	10.0	ARSENIC	89262	2.44	µg/l
	10.0	CHLOROFORM	89262	1.41	µg/l
AREA 4	3.8	ARSENIC	89261	2.74	µg/l
AREA 5	5.5	LEAD	89262	0.0796	µg/l
SW02003	5.0	MERCURY	88166	0.215	µg/l***

Lower Derby Lake:

Site ID	*Depth*	*Parameter*	*Date*	*Value*	*Units*
AREA 1	2.5	ARSENIC	89263	2.74	µg/l
AREA 2	6.0	ARSENIC	89264	2.44	µg/l
	6.0	CHLORDANE	89264	0.0119	µg/l***
AREA 3	3.5	ARSENIC	89263	2.74	µg/l
AREA 4	3.0	ARSENIC	89263	2.60	µg/l
AREA 5	3.0	ARSENIC	89263	2.44	µg/l

APPENDIX C - LAKE SEDIMENT CONTAMINATION

The following list contains the contaminants concentration detected in Lake Ladora and Lower Derby Lake sediments. Sampling locations are shown in Figures 1.0 and 2.0.

Lake Ladora :

Site Id	*Depth*	*Parameter*	*Date*	*Value*	*units*
AREA 1	0.0	ALDRIN	89264	0.0131	μg/g
		ATRAZINE		610.0	μg/g
		VAPONA		0.538	μg/g
		DIELDRIN		0.00409	μg/g
AREA 2	0.0	ALDRIN	89264	0.00718	μg/g
		ATRAZINE		850.0	μg/g
		DBCP		0.00359	μg/g
		VAPONA		0.258	μg/g
		DIELDRIN		0.00518	μg/g
AREA 3	11.5	ATRAZINE	89261	97.0	μg/g
		LEAD		21.6	μg/g
AREA 4	2.5	ALDRIN	89265	0.0240	μg/g
		ATRAZINE		2400.0	μg/g
		DBCP		0.0109	μg/g
		VAPONA		0.298	μg/g
		DIELDRIN		0.00551	μg/g
		MERCURY		1.090	μg/g
		LEAD		27.5	μg/g
		DDE		0.00825	μg/g
	20.0	ATRAZINE	89263	45.0	μg/g
		DBCP		0.0192	μg/g
AREA 5	3.5	ALDRIN	89268	0.0335	μg/g
		DBCP		0.0155	μg/g
		DIELDRIN		0.00611	μg/g
		ENDRIN		0.00921	μg/g
		LEAD		25.3	μg/g
		DDE		0.00629	μg/g
	4.5	ATRAZINE	89263	15.6	μg/g

Lower Derby Lake:

Site ID	*Depth*	*Parameter*	*Date*	*Value*	*Units*	AREA 1
AREA 1	2.8	ALDRIN	89269	0.0192	μg/g	
		ATRAZINE		1200.0	μg/g	
		DBCP		0.0188	μg/g	
		DIELDRIN		0.00579	μg/g.	
		MERCURY	89269	0.0857	μg/g	
		LEAD		33.8	μg/g	
AREA 2	6.8	ALDRIN	89268	0.00648	μg/g	
		ATRAZINE		2200	μg/g	
		DBCP		0.0109	μg/g	
		VAPONA		3.90	μg/g	
		MERCURY		0.161	μg/g	

Lower Derby Lake:

Site ID	*Depth*	*Parameter*	*Date*	*Value*	*Units*
AREA 2	6.8	MALATHION	89268	0.323	µg/g
		LEAD		25.1	µg/g
AREA 3	3.8	ALDRIN	89269	3.40	µg/g
		ATRAZINE		1900.0	µg/g
		CL6CP		0.0169	µg/g
		DBCP		0.0151	µg/g
		DIELDRIN		0.073	µg/g
		ENDRIN		0.0115	µg/g
		ISODRIN		0.100	µg/g
		LEAD		17.10	µg/g
		DDT		0.00795	µg/g

APPENDIX D - BIOTA CONTAMINATION

LAKE LADORA BIOTA CONTAMINATION : Dieldrin

BIOTA	*# OF SAMPLES*	*# OF DETECTIONS*	*CONCENTRATION*
Bluegill	5	5	0.049 to 0.098 µg/g
Largemouth Bass	5	5	0.062 to 0.53 µg/g
American Coot	5	5	0.11 to 0.18 µg/g

LAKE LADORA BIOTA CONTAMINATION : Endrin

BIOTA	*# OF SAMPLES*	*# OF DETECTIONS*	*CONCENTRATION*
Largemouth Bass	5	1	0.048 µg/g

LAKE LADORA BIOTA CONTAMINATION : Mercury

BIOTA	*# OF SAMPLES*	*# OF DETECTIONS*	*CONCENTRATION*
Bluegill	5	4	0.061 to 0.20 µg/g
Largemouth Bass	5	5	0.062 to 0.57 µg/g
American Coots	4	3	0.054 to 0.060 µg/g

LOWER DERBY LAKE BIOTA CONTAMINATION : Dieldrin

BIOTA	*# OF SAMPLES*	*# OF DETECTIONS*	*CONCENTRATION*
Bluegill	5	4	0.035 to 0.99 µg/g
Largemouth Bass	5	5	0.022 to 0.13 µg/g
Bullhead	5	2	0.035 to 0.040 µg/g
American Coots	2	2	0.15 to 1.1 µg/g

LOWER DERBY LAKE BIOTA CONTAMINATION : DDE

BIOTA	# OF SAMPLES	# OF DETECTIONS	CONCENTRATION
Largemouth Bass	5	4	0.080 to 0.10 µg/g
Killdeer	2	2	0.28 to 3.7 µg/g

LOWER DERBY LAKE BIOTA CONTAMINATION : Mercury

BIOTA	# OF SAMPLES	# OF DETECTIONS	CONCENTRATION
Bluegill	5	5	0.071 to 0.21 µg/g
Largemouth Bass	5	5	0.11 to 0.24 µg/g
Bullhead	5	5	0.055 to 0.086 µg/g
Killdeer	2	1	0.11 µg/g

APPENDIX E - WATER QUALITY CRITERIA SUMMARY

NAME	FRESH ACUTE	FRESH CHRONIC	FISH CONSUMPTION
ALDRIN	3.0	---	0.079 ng
ARSENIC	360.0	190.0	17.5 ng
CHLORDANE	2.4	0.0043	0.46 ng
CHLOROFORM	28,900	1,240	15.7 µg
CYANIDE	22.0	5.2	---
DDE	1,050	---	---
DDT	1.1	0.001	0.024 ng
DIELDRIN	2.5	0.0019	0.076 ng
ENDRIN	0.18	0.0023	---
LEAD	8.2	3.2	---
MALATHION	---	0.1	---
MERCURY	2.4	0.012	146 ng

APPENDIX F - ENVIRONMENTAL FATE OF CONTAMINANTS

The following list gives the environmental fate of selected contaminants found in the groundwater, surface water, lake sediments, and biota.

Analyte	Specific Gravity (g/ml)	Solubility (mg/l)	Environmental Fate
Aldrin	1.6	0.021	Persistent in soil and water. Decomposes to Dieldrin in soils (half life is from 4 to 5 years). Highly resistant to biodegradation.
Benzene	0.88(20°C)	1,700	Half-life in soil is approximately 1 month.
Carbon Tetrachloride	1.60(20°C)	810	Resistant to microbial degradation. Does not hydrolyze.
Chlordane	1.11(16°C)	0.13	Epoxidized to chlordene expoxide by soil bacteria. Slow reaction, resistant to decomposition, bioaccumulates
Chloroform	1.48(20°C)	8,300	Stable in the environment. Highly resistant to biodegradation. Highly volatile.
DBCP	2.09(14°C)	11,000	Stable in neutral and basic soils. Reacts with dilute inorganic bases. High affinity for adhering to organic matter and clay particles. Moderate volatility. Slowly degraded by hydrolysis and microbial action.
Dieldrin	1.75	0.084	Decomposition product of aldrin. Very persistent in soils (half-life=7 years). Hydrclysis is slow, moderate bioaccumulation. High affinity for adhering to organic matter and clay particles.
Endrin	1.7(25°C)	0.082	Half-life in soils 4 to 8 years. Rapidly transformed by sunlight to form a keytone.
Isodrin	1.6	0.17	Half-life in soils approximately 6 years. Byproduct of endrin.
DDE	1.6	0.08	Decomposition product of DDT. Resistant to biodegradation.
DDT	1.56	0.002	Persistent in soils.

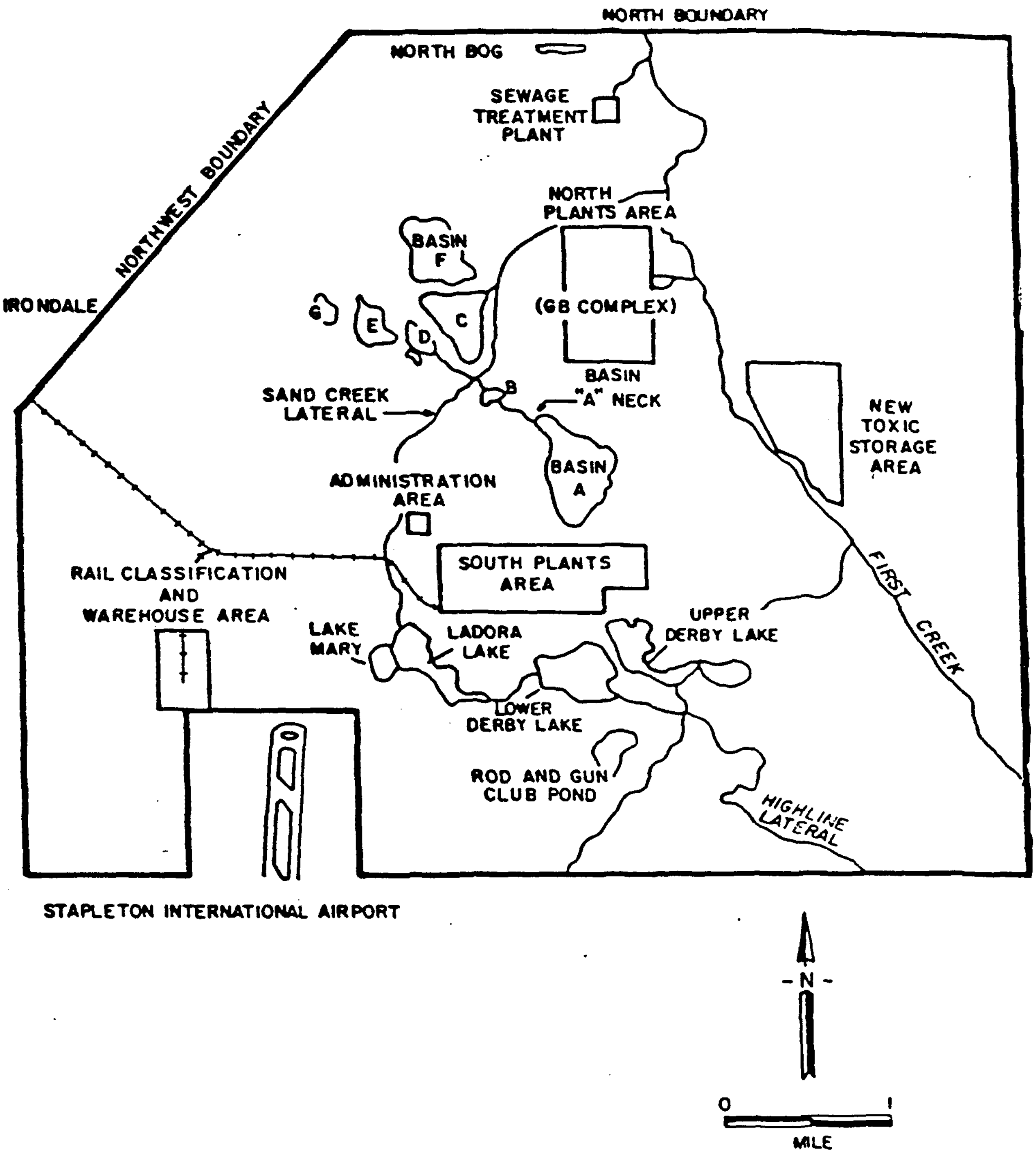

FIGURE 1.0 General Map of Rocky Mountain Arsenal

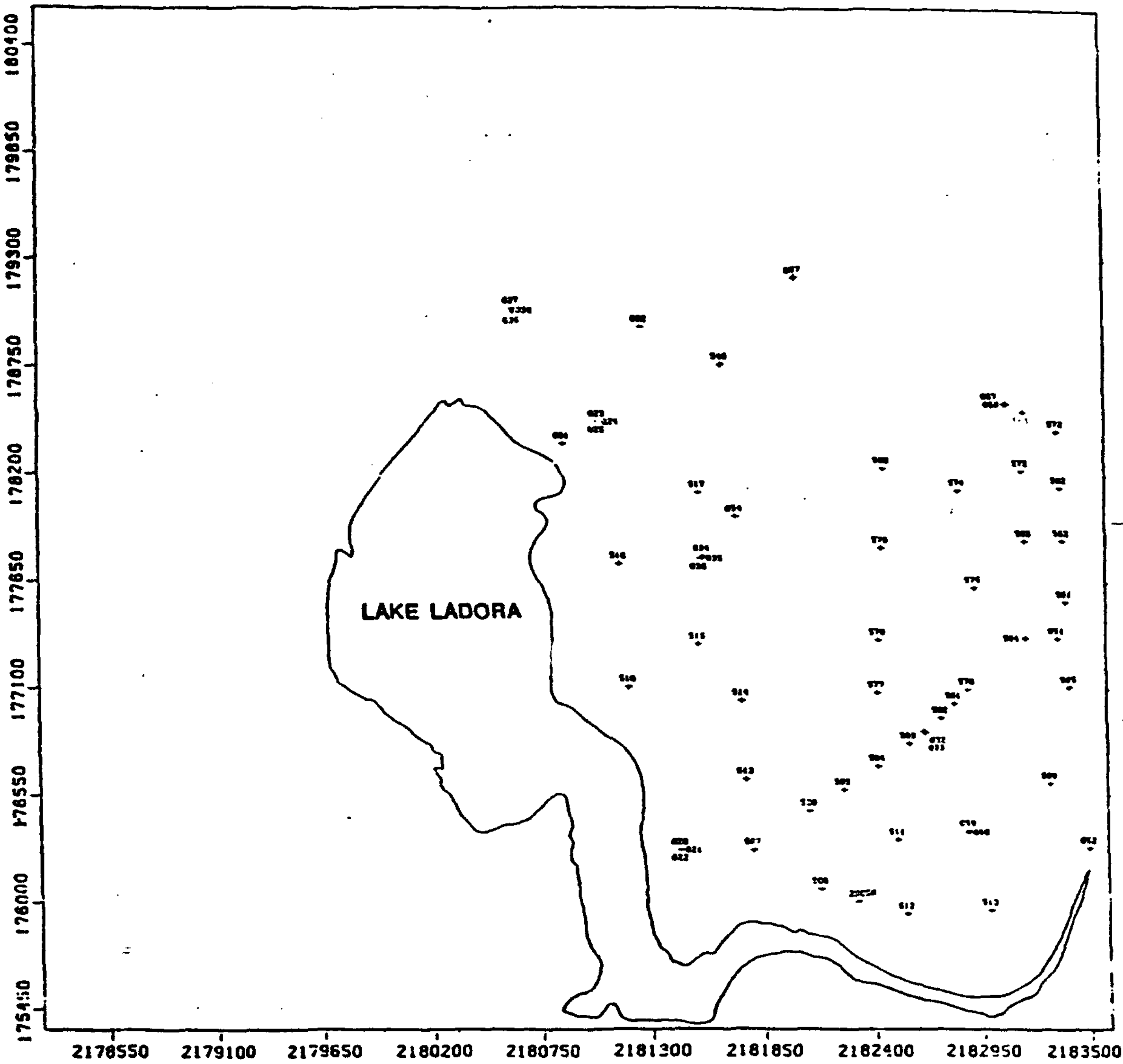

FIGURE 2.0 Lake Ladora Well Locations

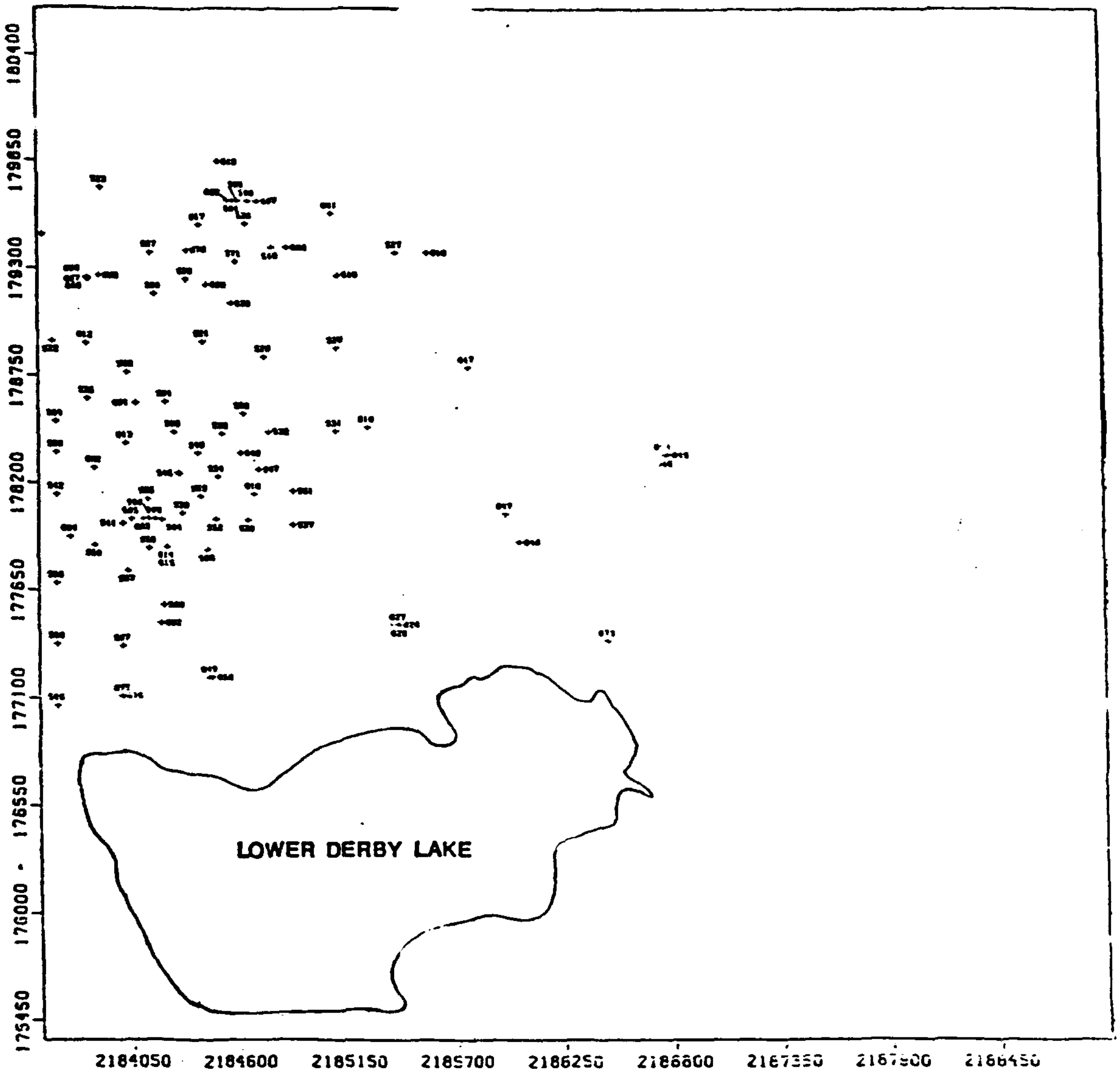

FIGURE 3.0 Monitor Well Locations

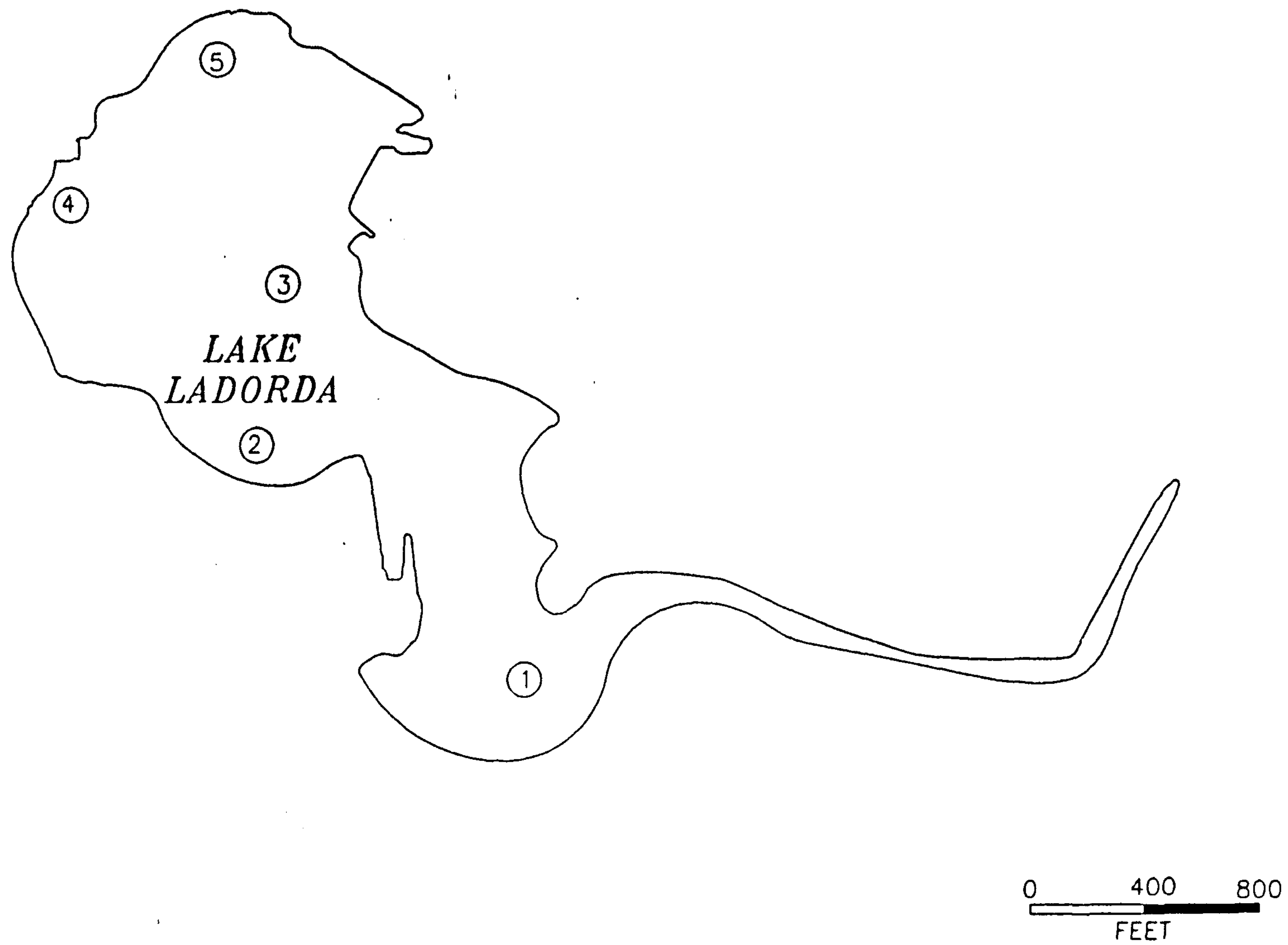

FIGURE 4.0 Sample Locations For Lake Ladora

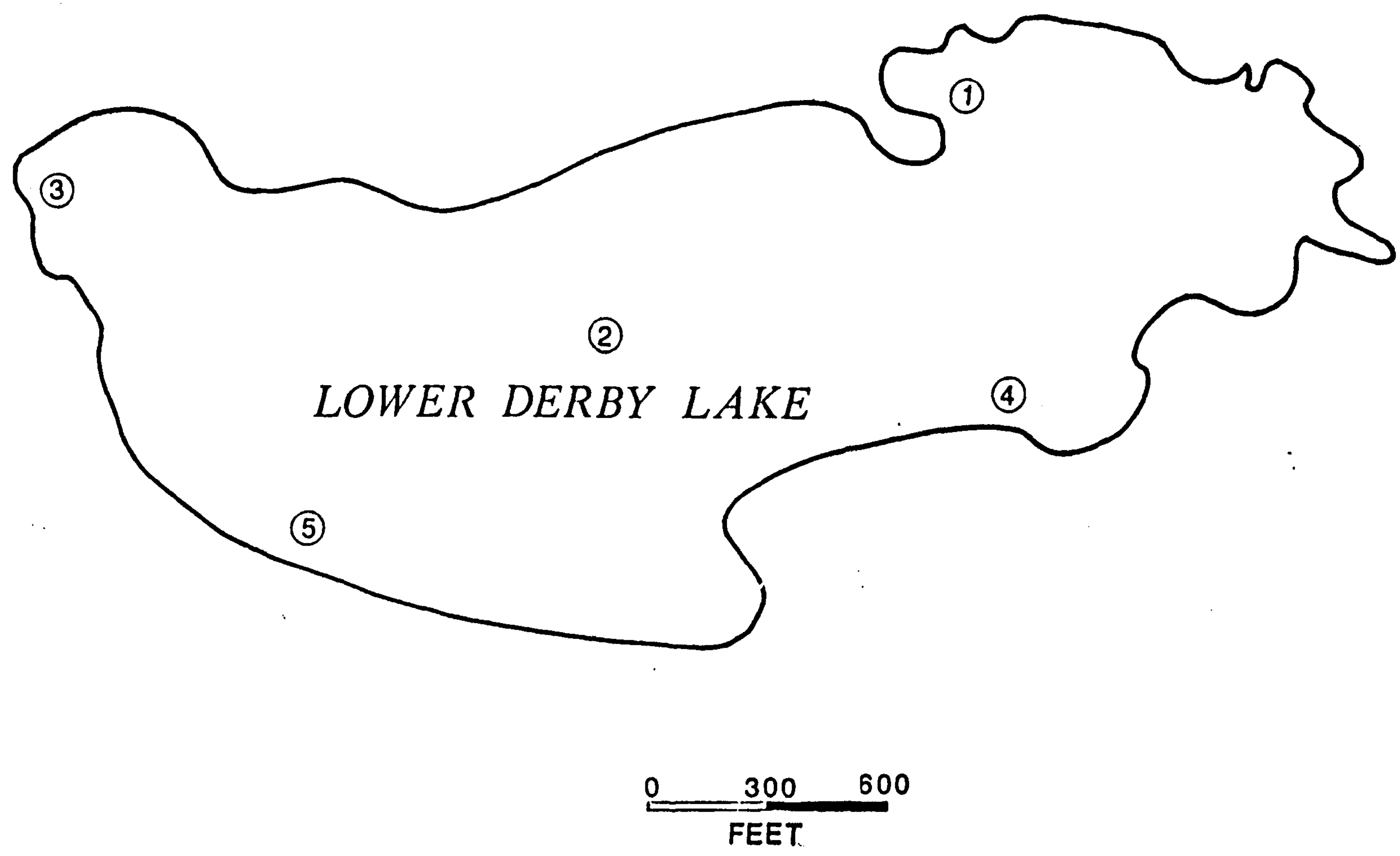

FIGURE 5.0 Sample Locations For Lower Derby Lake